

Generalized Foldy-Wouthuysen approach for the derivation of non-relativistic effective field theories

Speaker : Tobias ASANO (浅野トビアス) Ph.D. student

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Effective field theories (EFTs) provide a powerful framework for high-precision calculations at reduced complexity compared with their underlying fundamental theories. Since Lorentz invariance is no longer manifest in the non-relativistic (NR) regime, the construction of NREFTs [1] requires a different realization of the underlying symmetry, leading to relations among certain Wilson coefficients commonly referred to as hidden Lorentz invariance [2]. Such relations are well understood in established NREFTs on inertial flat spacetime, such as NRQED and NRQCD, while the corresponding symmetry structure is expected to become less transparent for theories involving physics beyond the Standard Model or non-inertial and curved spacetime backgrounds.

In this presentation, we show how the structure of an NREFT, including the relations associated with hidden Lorentz invariance, can instead be obtained by first constructing a relativistic EFT and subsequently performing a systematic NR reduction [3]. As an explicit example, we consider a relativistic EFT describing quantum electrodynamics and quantum chromodynamics on flat spacetime and derive the corresponding NRQED and NRQCD structures using a generalized reduction scheme based on an extended Foldy-Wouthuysen transformation [4]. This approach provides a systematic starting point for extending NREFT constructions to more general interactions and spacetime backgrounds.

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[2] R.J. Hill, G. Lee, G. Paz and M.P. Solon, Phys. Rev. D **87**, 053017 (2013)

[3] T. Asano, F. Di Pumpo, E. Giese and M. Bamba, arXiv:2609.01980

[4] L.L. Foldy and S.A. Wouthuysen, Phys. Rev. **78**, 29 (1950)

Organizer: Motoaki BAMBA (馬場 基彰 内線 4322)

